

CONFERENCE ON DISARMAMENT

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PROGRESS REPORT TO THE CONFERENCE ON DISARMAMENT ON THE THIRTY-FIFTH SESSION OF THE AD HOC GROUP OF SCIENTIFIC EXPERTS TO CONSIDER INTERNATIONAL COOPERATIVE MEASURES TO DETECT AND IDENTIFY SEISMIC EVENTS

1. The Ad Hoc Group of Scientific Experts to Consider International Cooperative Measures to Detect and Identify Seismic Events, initially established in pursuance of the decision taken by the Conference of the Committee on Disarmament on 22 July 1976, held its thirty-fifth formal session from 15 to 26 February 1993, in the Palais des Nations, Geneva, under the Chairmanship of Dr. Ola Dahlman of Sweden. This was the twenty-seventh session of the Group, convened under its new mandate by the decision of the Committee on Disarmament at its 48th meeting on 7 August 1979.
2. The Ad Hoc Group is open to all member States of the Conference on Disarmament. It is also open on a standing basis to all non-member States which have been invited upon their request by the Conference on Disarmament to participate in its work. Accordingly, scientific experts and representatives of the following member States of the Conference on Disarmament participated in the session: Australia, Belgium, Canada, China, Egypt, France, Germany, Hungary, India, Italy, Japan, Netherlands, Pakistan, Poland, Romania, Russian Federation, Sweden, United Kingdom of Great Britain and Northern Ireland and the United States of America.
3. Scientific experts and representatives from the following non-member States of the Conference on Disarmament participated in the session: Austria, Czech Republic, Finland, New Zealand, Norway, South Africa, Spain and Switzerland.
4. Upon invitation by the Conference on Disarmament, a representative of the International Atomic Energy Agency (IAEA) made a presentation which was appreciated by the Ad Hoc Group. The Group considers that its contact with IAEA should be maintained, with informal exchange of relevant information and experiences.
5. During the session 34 papers containing information on national investigations related to the work of the Group were presented by experts from: Australia, Canada, Czech Republic, Denmark, Finland, France, New Zealand, Norway, Russian Federation, South Africa, Sweden and United States of America.

6. The Ad Hoc Group completed a comprehensive seismological evaluation of its Second Technical Test (GSETT-2). The results are contained in the Group's Conference Room Paper 228, and a summary is annexed to this progress report. The Ad Hoc Group expressed its appreciation to Professor Hans-Peter Harjes of Germany, who coordinated this evaluation effort and drafted the evaluation report.

7. The Ad Hoc Group conducted in-depth discussions on the reassessment of the concept of a global system for the exchange of seismic data worked out in its Fifth Report (CD/903), based on material prepared by working groups of participating experts. The discussions were focused on the overall design and plans for future testing of the concept.

8. The Ad Hoc Group agreed that its overall goal is to design and test concepts for a system for international seismic data exchange which provides States with data and information for their national CTB verification needs. The Group noted that future monitoring environments and specific monitoring requirements will be set by participating States and may change over time. It is therefore impossible to establish a priori detailed requirements for the system. However, the Group agreed upon some important design goals for a future system:

- Prompt and direct access to all data which are essential to system operation;
- Convenient access to any supplementary relevant data that might be useful;
- The goals should be accomplished within realistic manpower and budget resources.

The Group agreed that it would be necessary to conduct a cost-performance analysis of global seismic networks of different configurations.

9. The Ad Hoc Group considered that the main elements in the envisaged global system should have the following characteristics:

(i) A global network of stations

This is a three-tiered network: The first tier, the alpha network, provides the primary detection and initial event location estimates for the global system. The second tier, the beta network, augments the alpha network by providing data to improve hypocentre determination for events detected by the alpha network. The third tier, the gamma network, is not formally a part of the system, but provides supplementary data and information considered by the National Data Centers (NDCs) to be important to improving the capability of the global system.

The seismological evaluation report of GSETT-2 noted that arrays were the most important stations in the GSETT-2 network and should be the backbone of any future monitoring system. The global network of stations, particularly the alpha network, should include arrays to the greatest degree practicable.

consider issues related to the design and implementation of a global monitoring system for CTB verification. Many participants of the Group were able to attend and contribute to the workshop. This aided in the Group's continued work. The Group expressed its support to the efforts by Egypt to provide basic seismological training and information on the work of the GSE to scientists in Africa and Arab countries. The Group also expressed its support to those countries which assisted Egypt in this important work.

13. The Ad Hoc Group suggests that its next session, subject to approval by the Conference on Disarmament, should be convened from 26 July to 6 August 1993, in Geneva.

ANNEX

Summary Report on the Seismological Evaluation of the Group of Scientific Experts' Second Technical Test (GSETT-2)

This annex summarizes the seismological evaluation of the Ad Hoc Group of Scientific Experts' Second Technical Test (GSETT-2) conducted from 22 April to 2 June 1991. The full evaluation report is contained in the Ad Hoc Group's Conference Room Paper 228. The report focuses on evaluating the detection and location performance achieved by the GSETT-2 network during the experiment. In addition, the reported magnitude values are discussed.

Sixty stations contributed data during GSETT-2, including 12 arrays and 48 single-site three-component stations. The global distribution of the participating stations was very heterogeneous, resulting in large regional variations in detection thresholds and location accuracies.

An analysis of the stations reporting the 3,715 events listed in the GSETT-2 Final Event Bulletins (FEBs) reveals the crucial importance of arrays to event detection and location. If no arrays had participated in GSETT-2, the remaining arrivals, reported by single stations only, would have been sufficient to define only 911 events.

The large database of seismic waveforms collected during GSETT-2 offered the first opportunity for a quantitative analysis of seismic station conditions and for studying their influence on spatial and temporal variations of the network detection performance. The noise amplitudes correlated well with geographic, tectonic and cultural station settings. Across the GSETT-2 network, noise amplitudes varied by more than a factor of 10 at frequencies near 1 Hz. This is the frequency range which is most important for teleseismic detection. In this frequency band, noise levels mainly decrease with increasing station distance to coast lines. In the high-frequency band (2-10 Hz), the noise level and its temporal variation decrease with decreasing density in the local human population and with increasingly competent emplacement geology (i.e. igneous or metamorphic lithologies).

An important aspect of the performance evaluation of GSETT-2 has been the completeness and quality of the Final Event Bulletin (FEB). The detection threshold of the GSETT-2 network was estimated by comparing the FEB to independent bulletins which are based on many more seismic stations, such as the Earthquake Data Report (EDR) of the United States Geological Survey. Moreover, the network detection performance was estimated by model simulations using the previously described station noise conditions. Both studies gave consistent results if the different model assumptions were taken into account.

During GSETT-2, the actually achieved 90 per cent detection threshold, using the EDR as a reference, was estimated at magnitude $m_b = 4.4$ in the northern hemisphere and $m_b = 5.1$ in the southern hemisphere. For the entire globe, the estimated 90 per cent detection threshold was $m_b = 4.7$. More precisely, this means that for a seismic event reported in the EDR of $m_b = 4.7$ or greater, there was at least a 90 per cent probability that the event appeared in the Final Event Bulletin (FEB) with a location difference less

than 3 degrees and an origin time difference less than one minute. It was noted that a number of additional events were reported in the FEBs, but with less accuracy in location and origin time. This suggests that the detection capability of the GSETT-2 network is significantly better than the threshold of $m_b = 4.7$, if the requirements to location accuracy are relaxed. This conclusion was supported by an evaluation of the detected initial phases at the GSETT-2 stations. Requiring two or more station detections to define an event, it was found that the 90 per cent global threshold for confirming events reported in the EDR (but not locating them) was as low as $m_b = 3.8$.

The heterogeneous global distribution of the GSETT-2 stations is reflected in a large variability of the detection performance. Fennoscandia had the best instrumental coverage during the experiment and consequently the best detection performance was achieved in this region. The 90 per cent detection threshold was estimated to be about magnitude 2.5. On the other hand, a poor detection performance (high detection threshold) close to magnitude 5 was estimated for regions with a sparse detection coverage, for example, parts of the southern hemisphere.

Besides the ever-present ambient noise, it is the so-called signal-generated noise which can occasionally influence the detection capability of a seismic network. During the time period of GSETT-2 a large earthquake occurred in the Western Caucasus, followed by numerous aftershocks. It was found that the resulting increase in detection threshold for the GSETT-2 network lasted a relatively short time and that stations detecting at high frequencies, such as regional arrays, are less affected than traditional stations by the interference from such events.

To evaluate the location performance achieved during GSETT-2, the same procedures were used as for the assessment of the detection performance. In general, there was a significant number of poorly located small events in the Final Event Bulletin (FEB). Taking the Earthquake Data Report (EDR) of the United States Geological Survey as a reference, the median location difference for the 765 common events was 37 km, with a remarkable scatter for individual events. On the positive side, the evaluation of the regional event location performance in Fennoscandia showed that in an area where the station coverage of the GSETT-2 network was good, the location accuracy approached that obtained by dense national networks. For events in Fennoscandia for which the true location was known from independent sources, the median FEB-location error was only about 10 km.

During GSETT-2, the 12 arrays provided slowness and azimuth data for most reported detections and 15 of the other 48 stations provided azimuth and angle of incidence values obtained from three-component processing. These directional data were used in event definition by the EIDCs. In the case of azimuth, the arrays out-performed the three-component stations by a factor which is substantially greater than the factor of two given in the event definition residual criteria. For slowness, the allowed a priori residuals seem to be met on average by arrays, but they were clearly too optimistic for three-component stations.

In general, the accuracy of slowness-vector estimates varied enormously among the three-component stations and arrays during GSETT-2. This variation

suggests that a longer observation period would be needed to calibrate stations and arrays on an individual basis in order to improve the quality of directional data used for epicentre determination.

Depth estimation of seismic events is an important discriminator between earthquakes and explosions because the latter are restricted to shallow depths of less than 10 km, a range in which only a small fraction of earthquakes occur. Much of the waveform analysis at the Experimental International Data Centres (EIDCs) was targeted towards improving the depth estimates and about one third of the FEB-events had at least one defining depth phase. It was found that it is difficult to determine depth accurately - in particular for small events, i.e. for magnitudes below $m_b = 4$. Almost no depth phases were found in the FEBs for events shallower than 10 km depth.

The most useful source parameter to describe the size of a seismic event is the magnitude. In the context of a seismic monitoring system, the body-wave magnitude m_b and the surface wave magnitude M_s have proved to be the most important scales. Also in describing the detection performance and the location accuracy in the previous sections, the magnitude scale has been essential. Unfortunately, there were insufficient and inconsistent data contained within the Final Event Bulletin (FEB) to make definite statements about magnitudes and magnitude scales with respect to the GSETT-2 database. Finally, a number of recommendations for the design of a future global system can be derived from the seismological evaluation of GSETT-2:

- If a homogeneous global detection and location performance of a future seismic network is desirable, the distribution of high-quality stations needs to be more uniform than during GSETT-2.
- Arrays were the most important stations in the GSETT-2 network and should be the "backbone" of any future monitoring system.
- Additional quality control measures should be made a specific part of the operating procedures at EIDCs and at stations and/or NDCs.
- The process of phase association and event location at EIDCs was more difficult than anticipated. Further development of association/location algorithms is required.
- Information from local and regional networks could have been better incorporated by the EIDCs. This information should be formalized so that it can automatically be interpreted by the EIDCs.
- To improve the three-component slowness vector estimate, a standard processing technique should be adopted for the whole network. The variation in the accuracy of slowness-vector estimates amongst three-component stations and arrays suggests a longer period of observation is needed to calibrate stations on an individual basis. An appropriate velocity model for each station should be used to convert from angle of incidence to slowness.
- Any future network should be calibrated with respect to standard travel-time curves and amplitude-distance relations. Station